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A hydraulic instability regulates cell death and Oocyte size selection in C.elegans germline

The process of making an oocyte starting from a germline tissue is a fundamental cellular process.Oogenesis demonstrates remarkable mechanical as well as hydrodynamic phenomena across organisms. Dynamic size regulation and mechanical symmetry breaking in germ cell population (within a syncytia) leads to heterogeneous growth leading to cell fate decisions. The roundworm C. elegans has a tubular syncytial (tissue architecture with connected cytoplasm) germline, which achieves germ-cell growth by hydrodynamic flows that range across 400 microns.

By quantitative analysis and theoretical modeling, we discover that germ cells actively generate long-range hydrodynamic flows along the germline, while also locally maintaining their homogenous size. The coupling of cell mechanics and hydrodynamic fields lead to active pressure-tuning, which yields a hydraulic instability setting a critical size for the germ-cells in the absence of active sources. This mechanism ensures selection and growth of germ cells beyond a critical size at the expense of smaller cells and is independent of the apoptotic machinery. We unravel the physical basis of oogenesis and cell elimination by combining cellular mechanics and active hydrodynamics. Our findings elucidate a novel connection of cell fate and mechanics of volume regulation, and proposes a cell death mechanism that is emergent out of cellular competition rather than programmed.

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